

structures on the first and the second patterns **112** and **114** may be previously removed by the etching process.

[0103] As illustrated above, in methods of forming patterns of semiconductor devices, in accordance with example embodiments, four first patterns **112** may be formed in the first region A by using one first preliminary mask pattern **182** and by performing the DPT process twice. In the second region B, due to the height difference from the first region A, the second pattern **114** in the second region B may not be divided into fine patterns. Instead, the desired size of the second pattern **114** may be maintained.

[0104] FIGS. **18** to **20** are cross-sectional views illustrating stages of a method of forming patterns of semiconductor devices in accordance with example embodiments. This method may include processes substantially the same as or similar to those illustrated with reference to FIGS. **2** to **17**, except for processes of forming the first and second spacers **192** and **194**. Thus, like reference numerals refer to like elements, and detailed descriptions thereon may be omitted below for purposes of brevity. Processes substantially the same or similar to those illustrated with reference to FIGS. **2** to **6** may be performed.

[0105] Referring to FIG. **18**, in the first region A, the first spacer layer **190** covering the first preliminary mask pattern **182** may be exposed. In the second region B, the photoresist layer **200** may be formed on the first spacer layer **190**, and thus the first spacer layer **190** may not be exposed. The first spacer layer **190** may be removed by an anisotropic etching process so that a portion of the first spacer layer **190** covering the first sacrificial pattern **162** may be partially removed.

[0106] In at least some example embodiments, the etching process may be performed until the portion of the first spacer layer **190** covering the first sacrificial pattern **162** may be removed to have a thickness that may be about half of the original thickness. Thus, the first sacrificial pattern **162** may be still covered by the first spacer layer **190**, and as such the first sacrificial pattern **162** may not be exposed. An upper surface of the third hard mask **140** may also be covered by the first spacer layer **190**.

[0107] A process substantially the same as or similar to that illustrated with reference to FIG. **8** may be performed to remove the photoresist layer **200** in the second region B.

[0108] Referring to FIG. **19**, the first spacer layer **190** and the first sacrificial pattern **162** may be removed by an anisotropic etching process. Thus, an upper surface of the third sacrificial pattern **152** may be exposed, and the exposed upper portion of the third hard mask layer **140** in the first region A may be partially removed. Unlike the process illustrated with reference to FIG. **9**, after the portion of the first spacer layer **190** remaining on the third hard mask layer **140** is removed, the third hard mask layer **140** may be removed. Thus, an amount of the etched portion of the third hard mask layer **140** in the etching process may be less than that of the etching process illustrated with reference to FIG. **9**.

[0109] In the second region B, the second sacrificial pattern **164** may have the second thickness **T2**, which is greater than the third thickness **T3** of the first sacrificial pattern **162**; and an upper surface of the second sacrificial pattern **164** may be protected by the first spacer layer **190**. When the first sacrificial pattern **162** is completely removed, the second sacrificial pattern **164** may not be completely removed.

[0110] In the process illustrated with reference to FIG. **9**, the first spacer layer **190** in the second region B may be etched while the portion of the first spacer layer **190** on the third sacrificial pattern **152** is completely and/or substantially removed. However, in the process illustrated with reference to FIG. **19**, the first spacer layer **190** may remain on the third sacrificial pattern **152**, and an amount of etching has to be increased such that the first sacrificial pattern **162** may be completely removed. Thus, the second sacrificial pattern **164** may have a seventh thickness **T7** less than the second thickness **T2** of FIG. **9**. Moreover, a fifth height difference **H5** may be generated between an upper surface of the third sacrificial pattern **152** in the first region A and an upper surface of the second sacrificial pattern **164** in the second region B. The fifth height difference **H5** may be less than the second height difference **H2**.

[0111] Processes substantially the same as or similar to those illustrated with reference to FIGS. **10** to **12** may be performed to form patterns shown in FIG. **20**.

[0112] Referring to FIG. **20**, the third and fourth mask patterns **132** and **134** may be formed on the first hard mask layer **120**. The third hard mask pattern **132** may be formed in the first region A to have a relatively small size, and the fourth hard mask pattern **134** may be formed in the second region B to have a relatively large size. In the first region A, the first spacer **192** may be removed, and in some cases, an upper portion of the first hard mask pattern **142** may be partially removed. The remaining first hard mask pattern **142** may have the fourth thickness **T4** from an upper surface of the third hard mask pattern **132** to an upper surface of the first hard mask pattern. In the second region B, the fourth sacrificial pattern **154** may be removed; however, the second hard mask pattern **144** may not be completely removed due to the height difference between the first and the second spacers **192** and **194**.

[0113] Thus, the second hard mask pattern **144** may have the fifth thickness **T5**, which is greater than the fourth thickness **T4**. At least a portion of the second spacer **194** may remain on the second hard mask pattern **144**. The second spacer **194** in FIG. **20** may have an eighth thickness **T8**, which is less than the sixth thickness **T6** of the second spacer **194** shown in FIG. **12**. A sixth height difference **H6**, which may be generated between an upper surface of the first hard mask pattern **142** in the first region A and a top surface of the second spacer **194** in the second region B. The sixth height difference **H6** may be less than the third height difference **H3**. The amount of the etched portion of the first spacer layer **190** in the etching process illustrated with reference to FIG. **18** may be controlled so that the height difference between the first hard mask pattern **142** and the second spacer **194** may be controlled.

[0114] In the method illustrated with reference to FIGS. **18** to **20**, before removing the photoresist layer **200**, half of the first spacer layer **190** in the first region A may be removed, and the rest of the first spacer layer **190** may be removed after removing the photoresist layer **200**. However, inventive concepts may not be limited thereto. The amount of removal of the first spacer layer **190** before and after removing the photoresist layer **200** may be controlled such that the height difference between the first hard mask pattern **142** and the second spacer **194** may have various values. The total amount of removal of the first spacer layer **190** may be constant or substantially constant.